684.2228 D2

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	:	Examiner: Unassigned
NAOTO SANO	)	
	:	Group Art Unit: Unassigned
Application No.: Unassigned	)	
(This is a divisional of Application No.	:	
09/285,672, filed April 5, 1999.)	)	
	:	
Filed: Concurrently Herewith	)	
	:	
For: EXPOSURE APPARATUS WITH	)	October 17, 2001
A PULSED LASER	:	

Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Prior to examination of the above-identified continued prosecution application, please enter the following amendments:

IN THE SPECIFICATION:

Before the first line, insert the following:

--This application is a divisional of copending Application No. 09/285,672, filed April 5, 1999, which is a divisional of Application No. 08/577,474, filed December 22, 1995, issued as U.S. Patent No. 5,969,799, on October 19, 1999.--.

Please substitute the paragraph beginning at page 1, line 4 and ending at line 15. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--This invention relates generally to an exposure apparatus and a device manufacturing method using the same. More particularly, the invention is concerned with an exposure apparatus as a stepper, for example, and a device manufacturing method using the same, suitable applicable to the manufacture of various devices such as ICs, LSIs, CCDs, liquid panels or magnetic heads, by, for example, illuminating a circuit pattern of a reticle with pulse light from an excimer laser, for example, and by projecting the illuminated circuit pattern onto a wafer.--.

Please substitute the paragraph beginning at page 1, line 16 and ending at line 25. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Recently, in an exposure method us an ultra-high pressure Hg lamp, various attempts have been made to enhance the resolution by changing the exposure wavelength to i-line from g-line. Also, many proposals have been made to use pulse light of <u>a</u> shorter wavelength, as represented by an excimer laser, to increase the resolution. The use of short wavelength light is effective to enlarge the depth of focus with the reduction in wavelength, to thereby improve the resolution.--.

Please substitute the paragraph beginning at page 1, line 26 and ending at page 2, line 15. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The emission spectrum of an excimer laser, in a case of a KrF excimer laser, for example, is about 300 pm (full width at half maximum), and this is sufficiently small as compared with the full width wavelength of light from conventional ultra-high pressure Hg lamps. Taking the quality into account, the optical material usable in a reduction projection lens of an exposure apparatus which uses light in the deep ultraviolet region might be synthetic quartz or fluorite only. For this reason, taking chromatic aberration into account, even with a spectral band width of 300 pm, which is sufficiently small as compared with that of ultra-high pressure Hg lamps, the band width has to be reduced (band-narrowed) further by about two digits. Namely, the full width at half maximum has to be not greater than 3 pm (0.003 nm).--.

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--For a reduction of the spectral band width, generally, a band narrowing unit having a dispersion element such as an etalon or grating is used to band narrow a laser light to a spectral band width of about 1 pm. While the emission center wavelength of the thus band narrowed laser light may differ with the laser medium used, usually a wavelength which is in the vicinity of the emission gain by which a maximum output is obtainable is selected. For example, in a case of a KrF excimer laser, it is close to 248.35 nm, which is the center of the emission gain.--

Please substitute the paragraph beginning at page 2, line 27 and ending at page 3, line 7. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--On the other hand, recent semiconductor device manufacturing apparatuses are required to provide a high resolution and yet a high throughput. Generally, the resolution depends on the numerical aperture (N.A.) of a projection lens system. Further, for a higher throughput, the size of a chip has become larger. This necessitates a projection lens system having a large N.A. and yet a wide field angle.--.

Please substitute the paragraph beginning at page 3, line 8 and ending at line 23. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--However, enlargement of the N.A. or the field angle of a projection lens system directly leads to a difficulty in lens design. Also, it results in a narrowed tolerance to production, making the lens manufacture more difficult. For the manufacture of a projection lens system, generally, a number of lenses are combined into a projection lens, and trial printing tests are carried out by using that projection lens system. Aberrations of the projection lens system are detected on the basis of the results of trial printing, and correction of the lens system is performed. However, this process needs the skill of an operator and takes much time. Thus, the throughput is low. Also, it is practically difficult to correct all products (projection lens systems) precisely and exactly.--.

Please substitute the paragraph beginning at page 3, line 24 and ending at page 4, line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--As for a method of quantitatively measuring the performance of a projection lens system having a combination of a number of lenses, there is a method in which an interferometer is used to detect aberrations and, on the basis of the detection, the lens system is corrected. Interferometers use a laser as a light source. However, in a case where an excimer laser is used in an exposure apparatus as a light source, there would be no laser source which is suitably usable in an interferometer and which has the same wavelength as that of the excimer laser. The excimer laser of the type used in the exposure apparatus may be used as a light source for the interferometer. However, the coherency of excimer lasers is not high, and they are not suited to be used as a light source of an interferometer. Additionally, because excimer outputs is difficult to attain. Thus, with an interferometer using an excimer laser, it is difficult to obtain good precision in inspection of the performance of a high-quality projection lens system having a large N.A. and/or a large field angle.--.

Please substitute the paragraph beginning at page 4, line 19 and ending at page 5, line 1. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Gas lasers such as a He-Ne laser have good coherency and they provide continuous wave emission. Thus, gas lasers may suitably be used as a light source of an interferometer. However, their wavelength differs considerably from that of excimer lasers. Thus, while taking chromatic aberration or film characteristics into account, it is difficult to use gas lasers for inspection of a projection lens system designed for use with the wavelength of an excimer laser.--.

Please substitute the paragraph beginning at page 5, line 2 and ending at line13. marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In the vicinity of 248.35 nm, which is the center wavelength of an ordinary KrF excimer laser, there is a double harmonic wave (a wave having a wavelength a half of its original wavelength) of an argon ion laser, which can be produced by using a secondary harmonic wave producing element. However such harmonics have a wavelength of about 100 pm, which is quite different from that of the KrF excimer laser. Thus, it cannot be used as a light source for an interferometer for inspection of a projection lens system designed for use with a band narrowed excimer laser.--.

Please substitute the paragraph beginning at page 5, line 20 and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In accordance with an aspect of the present invention, there is provided an exposure apparatus, comprising: irradiating means for projecting pulse light to a mask; and a projection optical system for projecting a pattern of the mask onto a substrate, wherein the pulse light has an adjusted wavelength such that it substantially coincides with a wavelength of laser light of a continuous wave.--.

Please substitute the paragraph beginning at page 6, line 15 and ending at line 24. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In accordance with a yet further aspect of the present invention, there is provided a device manufacturing method, comprising the steps of: providing a light source adapted to supply pulse light; and projecting the pulse light to a mask so that a pattern of the mask is projected through a projection optical system to a substrate, wherein the pulse light has an adjusted wavelength such that it substantially coincides with a wavelength of laser light of a continuous wave.--.

Please substitute the paragraph beginning at page 6, line 25 and ending at page 7, line 1. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

-- The projection optical system to be used in the present invention may include a lens assembly, a mirror assembly or a combination of a concave mirror and a lens assembly.--.

Please substitute the paragraph beginning at page 8, line 3 and ending at line 24. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 1 is a schematic and diagrammatic view of a main portion of an exposure apparatus according to a first embodiment of the present invention. Denoted in the drawing at 1 is light source means which comprises, for example, a KrF excimer laser for providing pulsed laser light. This excimer laser 1 provides pulse light of a wavelength of about 248 nm in the deep ultraviolet region. Denoted at 12 is a band narrowing unit which includes a band narrowing element, such as an etalon or grating, for example, for band narrowing the laser light from the excimer laser 1. Denoted at 3 is a wave meter for detecting the wavelength of

pulse light from the excimer laser 1, and denoted at 4 is a beam shaping optical system which serves to expand the beam diameter of the laser light. Denoted at 5 is an illumination optical system for uniformly illuminating a device pattern on the surface (surface to be illuminated) of a reticle R, placed on a reticle stage 10, with the laser light from the beam shaping optical system 4. Through this illumination optical system 5, the reticle surface is illuminated with a uniform illuminance distribution.--.

Please substitute the paragraph beginning at page 8, line 25 and ending at page 9, line 10. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Denoted at 6 is a projection optical system (projection lens system) for projecting, in a reduced scale, the circuit pattern (device pattern) on the reticle R surface onto the surface of a waver W placed on a wafer stage 7. Denoted at 9 is a controller which is operable to set and control various process conditions necessary for the projection exposure of the wafer W surface. Denoted at 11 is a laser controller for controlling the light source means 1 and the band narrowing unit 2 in accordance with the process conditions, set by the controller 9, so that the light source 1 provides pulse laser light of a predetermined wavelength.--.

Please substitute the paragraph beginning at page 9, line 24 and ending at page 10, line 11. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The emission conditions may include the energy of laser light per pulse, the emission frequency and the emission center wavelength, for example. The center wavelength of the laser light to be emitted may be at a level as automatically set by the laser controller 11, or it

may be at a level once set by the controller 9 and then transmitted to the laser controller 11. The laser controller 11 continuously monitors the emitted laser light by use of the wave meter 3 so that the emission wavelength from the excimer laser 1 is maintained at the set emission wavelength. Also, the laser controller 11 controls the band narrowing element (not shown) within the band narrowing unit 2, so that the wavelength of the pulse laser light is controlled at the set wavelength.--.

Please substitute the paragraph beginning at page 10, line 12 and ending at line 25. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--As regards the center wavelength to be set by the controller 9, in this embodiment, in a case where the light source means 1 used in the exposure apparatus comprises a KrF excimer laser, it is set at a wavelength 248.25 nm, which corresponds to the wavelength of the double or secondary harmonics of an argon ion laser (wavelength 496.5 nm) of a continuous emission type. While an argon ion laser has several emission lines, a wavelength of double harmonics of 496.5 nm having a relatively high power is close to the emission wavelength of the KrF excimer laser. Thus, the wavelength of exposure light in the exposure apparatus of this embodiment is adjusted or registered with that wavelength.--.

Please substitute the paragraph beginning at page 10, line 26 and ending at page 11, line 10. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The wavelength by which a maximum output is obtainable from the excimer laser 1, having been band narrowed by the band narrowing unit 2, is about 248.35 nm which is at the center of the gain. Thus, setting the emission wavelength of the excimer laser 1 at 248.25 nm results in a deviation of the wavelength by about 0.1 nm fro the wavelength by which a maximum output is obtainable. However, according to experiments made by the inventors of the subject application, a relation such as illustrated in Figure 2 has been obtained between the laser emission wavelength and the output.--.

Please substitute the paragraph beginning at page 11, line 11 and ending at line 22. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--More specifically, it has been found that, in a band narrowed KrF excimer laser, even if the set emission wavelength deviates by an order of 0.1 nm from the wavelength by which a maximum output is attainable, there occurs only a small drop in output of about a few percent. Generally, in exposure apparatuses, a large decrease in output leads to reduced illuminance on an image plane or degraded resolution, and it causes a serious problem. However, the small decrease of output found by the inventors can be easily compensated for by setting the optical system appropriately.--.

Please substitute the paragraph beginning at page 11, line 23 and ending at page 12, line 13. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In this embodiment, the design wavelength of the projection optical system 6 and the emission wavelength of the light source means 1 are registered with the wavelength of a high coherency and a continuous emission laser light source, for example, the wavelength of double harmonics (continuous wave) of laser light from an argon ion laser. Namely, the emission wavelength of the excimer laser is adjusted and registered with the wavelength of light from an argon ion laser. Several methods are applicable to registration of the wavelength to these lasers (the argon ion laser is provided with harmonic wave producing means).--.

Please substitute the paragraph beginning at page 12, line 1 and ending at page 13, line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 4 is an embodiment of an interferometer system, wherein the emission wavelength of a KrF excimer laser for providing pulse light with a center wavelength 248.25 nm, to be used in an exposure apparatus, is adjusted and registered with the wavelength of a double harmonics of a continuous emission type argon ion laser the optical performances of the projection optical system 6 is measured. In Figure 4, the laser light of a wavelength 496.5 nm from the argon ion laser 29 is wavelength-transformed by a wavelength transforming device 28, whereby a secondary harmonic wave (wavelength 248.25 nm) as the same or substantially the same wavelength of the KrF excimer laser is produced. It is then directed to a collimator lens 16 by which it is shaped into a desired beam diameter. Then, the light impinges on a half mirror 25.--.

Please substitute the paragraph beginning at page 12, line 27 and ending at page 13, line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 4 shows an embodiment of an interferometer system, wherein the emission wavelength of a KrF excimer laser for providing pulse light with center wavelength 248.25 nm, to be used in an exposure apparatus, is adjusted and registered with the wavelength of a double harmonics of a continuous emission type argon ion laser 29, having high coherency, and wherein by using the secondary harmonic wave from the argon ion laser, the optical performance of the projection optical system 6 is measured. In Figure 4, the laser light of a wavelength 496.5 nm from the argon ion laser 29 is wavelength-transformed by a wavelength transforming device 28, whereby a secondary harmonic wave (wavelength 248.25 nm) of the same or substantially the same wavelength of the KrF excimer laser is produced. It is then directed to a collimator lens 26 by which it is shaped into a desired beam diameter. The, the light impinges on a half mirror 25.--.

Please substitute the paragraph beginning at page 13, line 19 and ending at page 14, line 2. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The half mirror 25 reflects a portion of the received laser light, and this portion of the light is collected by a collimator lens 21 and is directed to the projection optical system 6. The projection optical system 6 collects the received light, and the collected light is then reflected by a spherical mirror 20 such that the light goes back along its oncoming path. the

light then passes the half mirror 25, and by means of an imaging lens 23, the light is projected on the surface of a CCD camera 24, as measurement light.--.

Please substitute the paragraph beginning at page 14, line 3 and ending at line 11. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--On the other hand, the remaining portion of the laser light impinging on the half mirror 25 passes it. The remaining portion of the light, transmitted through the half mirror 25, is reflected by a reference mirror 22 such that the light goes back along its oncoming path. The light is then reflected by the half mirror 25 and, by means of the imaging lens 23, it is projected on the surface of the CCD camera 24 as reference light.--.

Please substitute the paragraph beginning at page 14, line 12, and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The image is formed on the camera 24, based on the two light fluxes of measurement light and reference light provides an interference fringe (resulting from interference between the two light fluxes) which bears information related to aberration, for example, of the projection optical system 6. The interference fringe is analyzed by an image processing system 27, by which aberrations and the like of the projection optical system 6 are detected. Based on this detection, the optical performance of the projection optical system 6 is measured. Thus, the optical performance of the projection optical system can be well adjusted on the basis of the stabilized laser light as has been described, such that high resolution pattern printing is assured with the thus adjusted projection optical system.--.

Please substitute the paragraph beginning at page 15, line 1 and ending at line 5. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Next, an embodiment of a device manufacturing method which uses an exposure apparatus as has been described in the foregoing, will be explained. In this embodiment the invention is applied to the manufacture of semiconductor devices.--.

Please substitute the paragraph beginning at page 15, line 6 and ending at line 14. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 5 is a flow chart of the sequence of manufacturing a semiconductor device, such as a semiconductor chip (e.g., IC or LSI), a liquid crystal panel or a CCD, for example. Step 1 is a design process for designing the circuit of a semiconductor device. Step 2 is a process for manufacturing a mask on the basis of the circuit pattern design. Step 3 is a process for manufacturing a wafer by using a material such as silicon.--.

Please substitute the paragraph beginning at page 15, line 15 and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Step 4 is wafer process which is called a pre-process wherein, by using the so prepared mask and wafer, circuits are practically formed on the wafer through lithography. Step 5 subsequent to this is an assembling step which is called a post-process, wherein the wafer processed by step 4 is formed into semiconductor chips. This step includes assembling (dicing and bonding) and packaging (chip sealing). Step 6 is an inspection step wherein an operability

check, a durability check, and so on, of the semiconductor devices produced by step 5 are carried out. With these processes, semiconductor devices are finished and they are shipped (step 7).--.

Please substitute the paragraph beginning at page 16, line 27 and ending at page 17, line 13. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Further, while in the foregoing embodiments, the wavelength of a secondary harmonic wave of an argon ion laser is applied as the measurement wavelength of an interferometer, if the design wavelength of a projection optical system differs from that of the embodiments, the measurement wavelength should be changed with respect to the design wavelength. In that case, the wavelength of a secondary harmonic wave or tertiary harmonic wave of laser light from an argon laser or from any other gas laser may be used as the measurement wavelength, and the wavelength of a pulse light source to be used for the exposure process may be adjusted and registered to the measurement wavelength.--.

Please substitute the paragraph beginning at page 17, line 14 and ending at line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Further, in the foregoing embodiments, the invention has been described with reference to a step-and-repeat type exposure apparatus (stepper). However, the invention is applicable also to a step-and-scan type scanning exposure apparatus.--.

IN THE ABSTRACT:

Please replace the Abstract with the following Abstract:

--An exposure apparatus comprising (a) irradiating means for illuminating a mask with laser light from an excimer laser and (b) a projection optical system for projecting a pattern of the mask onto a substrate with the laser light, wherein a characteristic of the projection optical system is measured by use of a harmonic of a predetermined laser, and wherein the laser light from the excimer laser has a wavelength corresponding to that of the harmonic of the predetermined laser.--

IN THE CLAIMS:

Please cancel Claims 1 through 34 without prejudice to or disclaimer of the recited subject matter.

Please add Claims 35 through 40 as follows:

--35. A method of manufacturing a projection exposure apparatus having a pulse laser, said method comprising the steps of:

measuring an optical performance of a projection optical system, by producing an interference fringe which bears information related to aberration of the projection optical system, by use of a harmonic of a laser having a coherency higher than that of a pulse laser, and then by analyzing the interference fringe, wherein a wavelength of the harmonic of the laser corresponds to a design wavelength of the projection optical system and also corresponds to a wavelength of light from the pulse laser.

36. A method according to claim 35, wherein the pulse laser comprises an excimer laser.

37. A method according to claim 36, wherein the excimer laser includes means for narrowing a bandwidth of the light and for changing the wavelength of the light.

38. A method of manufacturing a projection exposure apparatus having a KrF excimer laser, said method comprising the steps of:

measuring an optical performance of a projection optical system, by producing an interference fringe which bears information related to aberration of the projection optical system, by use of a harmonic of an Argon laser, and then by analyzing the interference fringe, wherein a wavelength of the harmonic of the Argon laser corresponds to a design wavelength of the projection optical system and also corresponds to a wavelength of light from the KrF excimer laser.

39. A projection exposure apparatus manufactured in accordance with a method as recited in claim 38, wherein the apparatus includes a KrF excimer laser and a projection optical system for projecting a pattern onto a wafer with light from the KrF excimer laser.

40. A projection exposure apparatus manufactured in accordance with a method as recited in any one of claims 35 to 37, wherein the apparatus includes a pulse laser and a projection optical system for projecting a pattern onto a wafer with light from the pulse laser. --

REMARKS

Applicants request favorable consideration and allowance of the subject application in view of the preceding amendments and the following remarks.

To place the subject application in better form, the specification has been amended to correct minor informalities. No new matter has been added by these changes.

Claims 35 - 40 are presented for consideration. Claims 35 and 38 are independent. Applicant submits that these claims patentably define features of the method of manufacturing a projection exposure apparatus of the present invention.

Applicants submit that this application is in condition for allowance. Favorable consideration of the claims and an early passage to issue of the present application are requested.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

Attorney for Applicants
Steven E. Warner
Registration No. 33,326

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
Facsimile: (212) 218-2200

SEW:eyw/eab

684.2228 Div. II

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	:	Examiner: Unassigned
NAOTO SANO	)	
	:	Group Art Unit: Unassigned
Application No.: Unassigned (This is a divisional of Application No. 09/285,672, filed April 5, 1999.)	) :)	
	:	
Filed: Concurrently Herewith	)	
	:	
For: EXPOSURE APPARATUS WITH A PULSED LASER	) :	October 17, 2001

Commissioner for Patents
Washington, D.C. 20231

REQUEST FOR PERMISSION TO AMEND THE DRAWINGS

In accordance with U.S. Patent and Trademark Office procedures, enclosed are duplicate informal drawings of Figure 6, with proposed amendments shown in red ink. Applicant requests approval to amend the drawings as follows:

IN FIGURE 6:

In Step 13, change "ELCTRODE" to --ELECTRODE--.

Favorable consideration is requested.

Applicant's undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

Attorney for Applicant
Steven E. Warner
Registration No. 33,326

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New York, New York 10112-3801
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SEW:eyw/eab

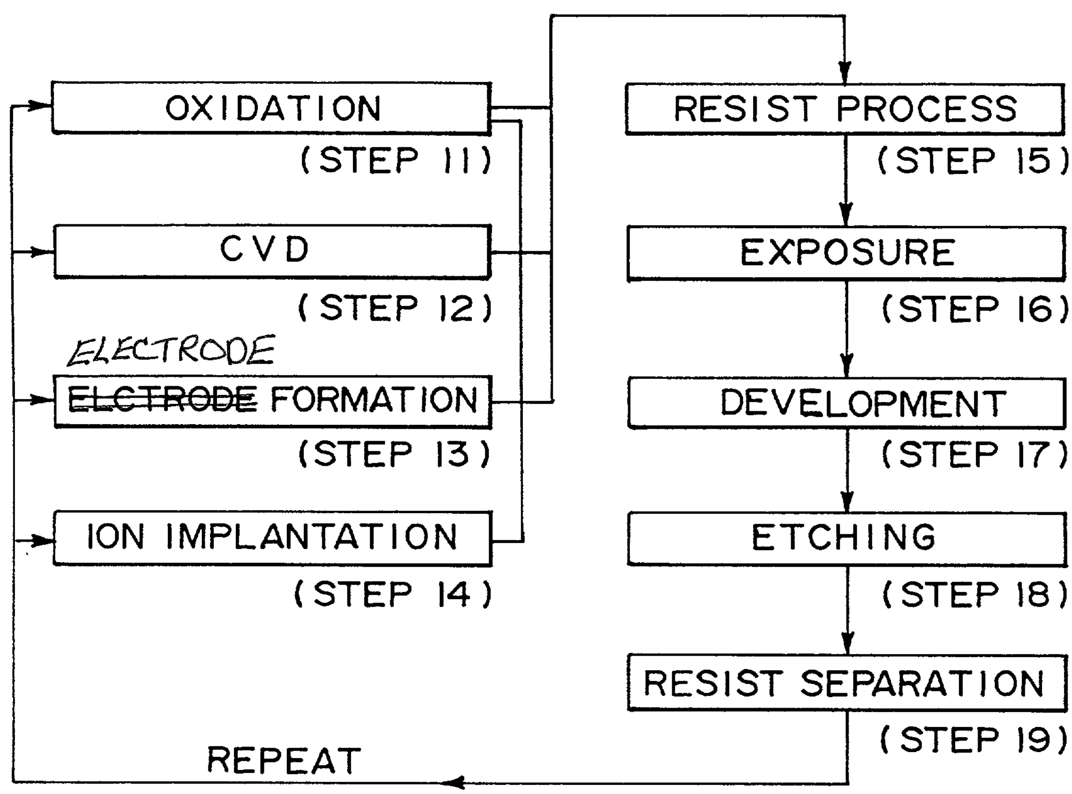
OXIDATION
(STEP 11)
CVD
(STEP 12)
ELECTRODE
~~ELCTRODE~~ FORMATION
(STEP 13)
ION IMPLANTATION
(STEP 14)
RESIST PROCESS
(STEP 15)
EXPOSURE
(STEP 16)
DEVELOPMENT
(STEP 17)
ETCHING
(STEP 18)
RESIST SEPARATION
(STEP 19)
REPEAT

FIG. 6

APPENDIX A

IN THE SPECIFICATION

Before the first line, insert the following:

This application is a divisional of copending Application No. 09/285,672, filed April 5, 1999, which is a divisional of Application No. 08/577,474, filed December 22, 1995, issued as U.S. Patent No. 5,969,799, on October 19, 1999.

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--The emission spectrum of an excimer laser, in a case of a KrF excimer laser, for example, is about 300 pm (full width at half maximum), and this is sufficiently small as compared with the full width wavelength of light from conventional ultra-high pressure Hg lamps. Taking the quality into account, the optical material usable in a reduction projection lens of an exposure apparatus which uses light in the deep ultraviolet region might be synthetic quartz or fluorite only. For this reason, taking chromatic aberration into account, even with a spectral band width of 300 pm, which is sufficiently small as compared with that of ultra-high pressure Hg lamps, the band width has to be reduced (band-narrowed) further by about two digits. Namely, the full width at half maximum has to be not greater than 3 pm (0.003 nm).--.

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--However, enlargement of the N.A. or the field angle of a projection lens system directly leads to a difficulty in lens design. Also, it results in a narrowed tolerance to production, making the lens manufacture more difficult. For the manufacture of a projection lens system, generally, a number of lenses are combined into a projection lens, and trial printing tests are carried out by using that projection lens system. Aberrations of the projection lens system are detected on the basis of the results of trial printing, and correction of the lens system is performed. However, this process needs the skill of an operator and takes much time. Thus, the throughput is low. Also, it is practically difficult to correct all products (projection lens systems) precisely and exactly.--.

Please substitute the paragraph beginning at page 3, line 24 and ending at page 4, line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--As for a method of quantitatively measuring the performance of a projection lens system having a combination of a number of lenses, there is a method in which an interferometer is used to detect aberrations and, on the basis of the detection, the lens system is corrected. Interferometers use a laser as a light source. However, in a case where an excimer laser is used in an exposure apparatus as a light source, there would be no laser source which is suitably usable in an interferometer and which has the same wavelength as that of the excimer laser. [Excimer] The excimer laser of the type used in the exposure apparatus may be used as a light source for the interferometer. However, the coherency of excimer lasers is not high, and

they are not suited to be used as a light source of an interferometer. Additionally, because excimer outputs is difficult to attain. Thus, [through] with an interferometer [with] using an excimer laser, it is difficult to obtain good precision in inspection of the performance of a high-quality projection lens system having a large N.A. and/or a large field angle.--.

Please substitute the paragraph beginning at page 4, line 19 and ending at page 5, line 1. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Gas lasers such as a He-Ne laser have good coherency and they provide continuous wave emission [of continuous wave]. Thus, gas lasers may suitably be used as a light source of an interferometer. However, [the] their wavelength differs considerably from that of excimer lasers. Thus, while taking chromatic aberration or film [characteristic] characteristics into account, it is difficult to use gas lasers for inspection of a projection lens system designed for use with the wavelength of an excimer laser.--.

Please substitute the paragraph beginning at page 5, line 2 and ending at line13. marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In the vicinity of 248.35 nm, which is the center wavelength of an ordinary KrF excimer laser, there is a double harmonic wave (a wave having a wavelength a half of its original wavelength) of an argon ion laser, which can be produced by using a secondary harmonic wave producing element. However such harmonics [has] have a wavelength of about

100 pm, which is quite different from that of the KrF excimer laser. Thus, it [can not] cannot be used as a light source for an interferometer for inspection of a projection lens system designed for use with a band narrowed excimer laser.--.

Please substitute the paragraph beginning at page 5, line 20 and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In accordance with an aspect of the present invention, there is provided an exposure apparatus, comprising: irradiating means for projecting pulse light to a mask; and a projection optical system for projecting a pattern of the mask onto a substrate,[;] wherein the pulse light has an adjusted wavelength such that it substantially coincides with a wavelength of laser light of a continuous wave.--.

Please substitute the paragraph beginning at page 6, line 15 and ending at line 24. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In accordance with a yet further aspect of the present invention, there is provided a device manufacturing method, comprising the steps of: providing a light source adapted to supply pulse light; and projecting the pulse light to a mask so that a pattern of the mask is projected through a projection optical system to a substrate,[;] wherein the pulse light has an adjusted wavelength such that it substantially coincides with a wavelength of laser light of a continuous wave.--.

Please substitute the paragraph beginning at page 6, line 25 and ending at page 7, line 1. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--[Projection] The projection optical system to be used in the present invention may include a lens assembly, a mirror assembly or a combination of a concave mirror and a lens assembly.--.

Please substitute the paragraph beginning at page 8, line 3 and ending at line 24. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 1 is a schematic and diagrammatic view of a main portion of an exposure apparatus according to a first embodiment of the present invention. Denoted in the drawing at 1 is light source means which comprises, for example, a KrF excimer laser for providing pulsed laser light. This excimer laser 1 provides pulse light of a wavelength of about 248 nm in the deep ultraviolet region. Denoted at 12 is a band narrowing unit which includes a band narrowing element, such as an etalon or grating, for example, for band narrowing the laser light from the excimer laser 1. Denoted at 3 is a wave meter for detecting the wavelength of pulse light from the excimer laser 1, and denoted at 4 is a beam shaping optical system which serves to expand the beam diameter of the laser light. Denoted at 5 is an illumination optical system for uniformly illuminating a device pattern on the surface (surface to be illuminated) of a reticle R, placed on a reticle stage 10, with the laser light from the beam shaping optical system

4. Through this illumination optical system 5 [10], the reticle surface is illuminated with a uniform illuminance distribution.--.

Please substitute the paragraph beginning at page 8, line 25 and ending at page 9, line 10. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Denoted at 6 is a projection optical system (projection lens system) for projecting, in a reduced scale, the circuit pattern (device pattern) on the reticle R surface onto the surface of a waver W placed on a wafer stage 7. Denoted at 9 is a controller which is operable to set and control various process conditions necessary for the projection exposure of the wafer W surface. Denoted at 11 is a laser controller for controlling the light source means 1 [11] and the band narrowing unit 2 in accordance with the process conditions, set by the controller 9, so that the light source 1 provides pulse laser light of a predetermined wavelength.--.

Please substitute the paragraph beginning at page 9, line 24 and ending at page 10, line 11. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The emission conditions may include the energy of laser light per pulse, the emission frequency and the emission center wavelength, for example. The center wavelength of the laser light to be emitted may be at a level as automatically set by the laser controller 11, or it may be at a level once set by the controller 9 and then transmitted to the laser controller 11. The laser controller 11 continuously monitors the emitted laser light by use of the wave meter 3 so

that the emission wavelength from the excimer laser 1 is maintained at the set emission wavelength. Also, the laser controller 11 controls the band narrowing element (not shown) within the band narrowing unit 2, so that the wavelength of the pulse laser light is controlled at the set wavelength.--.

Please substitute the paragraph beginning at page 10, line 12 and ending at line 25. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--As regards the center wavelength to be set by the controller 9, in this embodiment, in a case where the light source means 1 used in the exposure apparatus comprises a KrF excimer laser, it is set at a wavelength 248.25 nm, which corresponds to the wavelength of the double or secondary harmonics of an argon ion laser (wavelength 496.5 nm) of a continuous emission type. While an argon ion laser [have] has several emission lines, a wavelength of double harmonics of 496.5 nm having a relatively high power is close to the emission wavelength of the KrF excimer laser. Thus, the wavelength of exposure light in the exposure apparatus of this embodiment is adjusted or registered with that wavelength.--.

Please substitute the paragraph beginning at page 10, line 26 and ending at page 11, line 10. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The wavelength by which a maximum output is obtainable from the excimer laser 1, having been band narrowed by the band narrowing unit 2, is about 248.35 nm which is at the center of the gain. Thus, setting the emission wavelength of the excimer laser 1 at 248.25 nm results in [that] a deviation of the wavelength [deviates] by about 0.1 nm fro the wavelength by which a maximum output is obtainable. However, according to experiments made by the inventors of the subject application, a relation such as illustrated in Figure 2 has been obtained between the laser emission wavelength and the output.--.

Please substitute the paragraph beginning at page 11, line 11 and ending at line 22. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--More specifically, it has been found that, in a band narrowed KrF excimer laser, even if the set emission wavelength [is deviated] deviates by an order of 0.1 nm from the wavelength by which a maximum output is attainable, there occurs only a small drop [of] in output of about a few [percentages] percent. Generally, in exposure apparatuses, a large decrease in output leads to reduced illuminance on an image plane or degraded resolution, and it causes a serious problem. However, [a] the small decrease of output [as having been] found by the inventors can be easily compensated for by setting the optical system appropriately.--.

Please substitute the paragraph beginning at page 11, line 23 and ending at page 12, line 13. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In this embodiment, the design wavelength of the projection optical system 6 and the emission wavelength of the light source means 1 are registered with the wavelength of a high coherency and a continuous emission laser light source, for example, the wavelength of double harmonics (continuous wave) of laser light from an argon ion laser. Namely, the emission wavelength of the excimer laser is adjusted and registered with the wavelength of light from an argon ion laser. Several methods are applicable to registration of the wavelength to these lasers (the argon ion laser is provided with harmonic wave producing means).--.

Please substitute the paragraph beginning at page 12, line 1 and ending at page 13, line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 4 is an embodiment of an interferometer system, wherein the emission wavelength of a KrF excimer laser for providing pulse light with a center wavelength 248.25 nm, to be used in an exposure apparatus, is adjusted and registered with the wavelength of a double harmonics of a continuous emission type argon ion laser the optical performances of the projection optical system 6 is measured. In Figure 4, the laser light of a wavelength 496.5 nm from the argon ion laser 29 is wavelength-transformed by a wavelength transforming device 28, whereby a secondary harmonic wave (wavelength 248.25 nm) [of] as the same or substantially

the same wavelength of the KrF excimer laser is produced. It is then directed to a collimator lens [6] 16 by which it is shaped into a desired beam diameter. Then, the light impinges on a half mirror 25.--.

Please substitute the paragraph beginning at page 12, line 27 and ending at page 13, line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 4 shows an embodiment of an interferometer system, wherein the emission wavelength of a KrF excimer laser for providing pulse light with center wavelength 248.25 nm, to be used in an exposure apparatus, is adjusted and registered with the wavelength of a double harmonics of a continuous emission type argon ion laser 29, having high coherency, and wherein by using the secondary harmonic wave from the argon ion laser, the optical performance of the projection optical system 6 is measured. In Figure 4, the laser light of a wavelength 496.5 nm from the argon ion laser 29 is wavelength-transformed by a wavelength transforming device 28, whereby a secondary harmonic wave (wavelength 248.25 nm) of the same or substantially the same wavelength of the KrF excimer laser is produced. It is then directed to a collimator lens [6] 26 by which it is shaped into a desired beam diameter. The, the light impinges on a half mirror 25.--.

Please substitute the paragraph beginning at page 13, line 19 and ending at page 14, line 2. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The half mirror 25 reflects a portion of the received laser light, and this portion of the light is collected by a collimator lens 21 and is directed to the projection optical system 6. The projection optical system 6 collects the received light, and the collected light is then reflected by a spherical mirror 20 such that the light goes back along its oncoming path. the light then passes the half mirror 25, and by means of an imaging lens 23, the light is projected on the surface of a CCD camera 24, as measurement light.--.

Please substitute the paragraph beginning at page 14, line 3 and ending at line 11. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--On the other hand, the remaining portion of the laser light impinging on the half mirror 25 passes it. The remaining portion of the light, transmitted through the half [mirror] mirror 25, is reflected by a reference mirror 22 such that the light goes back along its oncoming path. The light is then reflected by the half mirror 25 and, by means of the imaging lens 23, it is projected on the surface of the CCD camera 24 as reference light.--.

Please substitute the paragraph beginning at page 14, line 12, and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--The image is formed on the camera 24, based on the two light fluxes of measurement light and reference light provides an interference fringe (resulting from interference between the two light fluxes) which bears information related to aberration, for example, of the projection optical system 6. The interference fringe is analyzed by an image processing system 27, by which aberrations and the like of the projection optical system 6 are detected. Based on this detection, the optical performance of the projection optical system 6 is measured. Thus, the optical performance of the projection optical system can be well adjusted on the basis of the stabilized laser light as has been described, such that high resolution pattern printing is assured with the thus adjusted projection optical system.--.

Please substitute the paragraph beginning at page 15, line 1 and ending at line 5. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Next, an embodiment of a device manufacturing method which uses an exposure apparatus as has been described in the foregoing, will be explained. In this embodiment the invention is applied to the manufacture of semiconductor devices.--.

Please substitute the paragraph beginning at page 15, line 6 and ending at line 14. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 5 is a flow chart of the sequence of manufacturing a semiconductor device, such as a semiconductor chip ([e.g.] e.g., IC or LSI), a liquid crystal panel or a CCD, for

example. Step 1 is a design process for designing the circuit of a semiconductor device. Step 2 is a process for manufacturing a mask on the basis of the circuit pattern design. Step 3 is a process for manufacturing a wafer by using a material such as silicon.--.

Please substitute the paragraph beginning at page 15, line 15 and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Step 4 is wafer process which is called a pre-process wherein, by using the so prepared mask and wafer, circuits are practically formed on the wafer through lithography. Step 5 subsequent to this is an assembling step which is called a post-process, wherein the wafer processed by step 4 is formed into semiconductor chips. This step includes assembling (dicing and bonding) and packaging (chip sealing). Step 6 is an inspection step wherein <u>an</u> operability check, <u>a</u> durability check, and so on, of the semiconductor devices produced by step 5 are carried out. With these processes, semiconductor devices are finished and they are shipped (step 7).--.

Please substitute the paragraph beginning at page 16, line 27 and ending at page 17, line 13. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Further, while in the foregoing embodiments, the wavelength of a secondary harmonic wave of an argon ion laser is applied as the measurement wavelength of an interferometer, if the design wavelength of a projection optical system differs from that of the

embodiments, the measurement wavelength should be changed with respect to the design wavelength. In that case [occasion], the wavelength of a secondary harmonic wave or tertiary harmonic wave of laser light from an argon laser or from any other gas laser may be used as the measurement wavelength, and the wavelength of a pulse light source to be used for the exposure process may be adjusted and registered to the measurement wavelength.--.

Please substitute the paragraph beginning at page 17, line 14 and ending at line 18. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Further, in the foregoing embodiments, the invention has been described with reference to a step-and-repeat type exposure apparatus (stepper). However, the invention is applicable also to a step-and-scan type scanning exposure apparatus.--.

IN THE ABSTRACT:

Please replace the Abstract with the following Abstract:

--An exposure apparatus comprising (a) irradiating means for illuminating a mask with laser light from an excimer laser and (b) a projection optical system for projecting a pattern of the mask onto a substrate with the laser light, wherein a characteristic of the projection optical system is measured by use of a harmonic of a predetermined laser, and wherein the laser light from the excimer laser has a wavelength corresponding to that of the harmonic of the predetermined laser. [for projecting pulse light to a mask, and a projection optical system for

projecting pattern of the mask onto a substrate, wherein the pulse light has an adjusted wavelength such that it substantially coincides with a wavelength of laser light of continuous wave.]--.